CATERPILLAR®

3600 Marine Engine Application and Installation Guide

- Introduction
- General Information

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Introduction

Foreward

Introduction

The information presented in this guide should aid in the planning through customer acceptance phases of a project.

The guide is arranged and designed to enable the information to be kept current, and for the user to easily locate the specific information required.

The technical data included is for ease of reference and will be updated periodically. Dealers can also obtain current engine information by accessing the Caterpillar Technical Marketing Information System (TMI). This system should always be checked for the most up to date engine data available. The TMI System is a corporately oriented computerized system for collecting, preparing, maintaining, and communicating technical data required for marketing Caterpillar Engine Division products. TMI operates in an IMS environment through the Caterpillar Network and functions under a corporate security system.

It must always be emphasized to refer to the TMI System for the latest engine performance information on all Engine Division products.

Foreword

Proper selection and installation of engines for marine application is vital for dependable performance and long, trouble-free life. The purpose of this guide is to help:

- Make knowledgeable choices of power equipment.

- Design and build marine installations that perform reliably at an optimum price/value relationship to the customer.

To ensure engines are installed properly, Caterpillar has support capability unmatched in the industry. From disciplines required for installation, to service and maintenance demanded years after completion, Caterpillar continues its commitment to its customer's successful operation.

Over fifty years of developing marine power equipment has culminated in a broad line of practical equipment, providing cost-effective selection and installation ease. A single source for propulsion engines and marine auxiliaries assures testing and quality for matched packages.

Development of installation knowledge parallels equipment advances. While this Application and Installation Guide summarizes many aspects of installation, Caterpillar Dealers stand ready with complete and detailed assistance.

It is the installer's responsibility to consider and avoid possible hazardous conditions which could develop from the systems involved in a specific engine installation. The suggestions provided in this guide regarding avoidance of hazardous conditions apply to all applications and are necessarily of a general nature since only the installer is familiar with the details of a particular installation. The suggestions provided in this guide should be considered as general examples only, and are in no way intended to cover every possible hazard in all installations.

Use the table of contents as a checklist of subjects affecting engine installations. Using the indexed material during preliminary project planning can avoid the effort and expense of after-installation changes.

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General Information

- Model Identification
- Basic Engine Consists
- Engine Description
- Engine Testing and Certificates
- Torsional Vibration Analysis
- Engine Preservation and Packaging
- Shipbuilder's Responsibility
- Customer Application Information

Model Identification

The basic model number is representative of both the series of particular engine and the number of cylinders. Typically an additional suffix refers to the type of fuel injection method and charge air aspiration.

Example: 3612 DITA

Caterpillar 3600 Family	- 36
12 Cylinder Vee Engine	- 12
Direct Fuel Injected	- DI
Turbocharged Aftercooled	- TA

All Caterpillar engines have three numbers which further define the engine. They are:

Arrangement Number

Used to establish the specific part assemblies representing the basic engine. Components such as cylinder heads, pistons, cylinder blocks and crankshafts can be determined from the arrangement number. It is found on both the Serial Number Plate and Engine Information Plate, Figures 1 & 2. Both plates are located on the engine.

Serial Number

Each engine is assigned a unique serial number. The number typically consists of alpha numeric characters; the first three represent the engine model, i.e.:

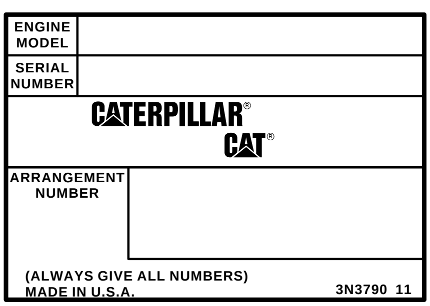
Model	Serial Number
3606	8RBXXXXX
3608	6MCXXXXX
3612	9RCXXXXX
3616	1PDXXXXX

The number is found on both the Serial Number Plate and the Information Plate.

Performance Specification Number

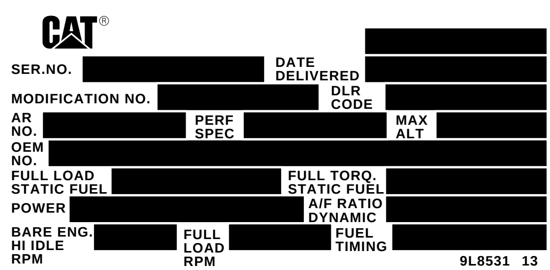
A number describing the engine's fuel system, air induction system, and performance settings. The number is unique to the power rating of each engine. It is found on the Engine Information Plate, Figure 2.

The three numbers are used to reference a specific engine model, application and rating and should always be referred to in correspondence relative to a particular engine or when spare parts are ordered.



Located on the left side of the engine block above one of the crankshaft inspection covers.

Figure 1



Located on the right side of the engine block above one of the crankshaft inspection covers.

Figure 2

Basic Engine Consists

The Caterpillar 3600 Family is configured in a positive-build manner for optimum flexibility in meeting customer requirements and ensures the ability to assemble and test a runnable engine at the factory.

Engine options, from Caterpillar's Selection Guide LEBQ5043, are listed in general code categories. The Selection Guide is included in the 3600 Sales Manual, LEKQ6141, and is available from Caterpillar Dealers or through the Caterpillar Corporate Literature distribution system.

The lists specify functional requirements of an engine resulting in a series of code numbers uniquely describing the complete engine package.

It should be emphasized that each specific engine is optimized in configuration hardware for the intended application, including core hardware such as cylinder liners, fuel injectors, camshafts, turbochargers, etc. The hardware differences to obtain maximum engine durability and performance efficiency, even for various fuel types, are all defined by the engine ordering code system.

Reference Material

LEKQ6141 3600 Sales Manual
LEBQ5043 3600 Attachment Selection Guide

Engine Description

The 3600 Engine Family is a modern, highly efficient engine family consisting of inline 6 and 8 cylinder engines and vee engines of 12 and 16 cylinders. They are 4 stroke non-reversible engines rated at speeds from 720 to 1000 rpm and intended for use as main propulsion and marine auxiliary engines for ship service generators. They are turbocharged and aftercooled with a direct injection fuel system using unit fuel injectors. For specification sheet information see the *Engine Data* section of this guide.

Cylinder Block

The cylinder block is a one piece casting of heavily ribbed, weldable, gray iron alloy. It is cast and machined at Caterpillar's facilities. Air intake plenums run the full length of the engine providing even air distribution to the cylinders. Inspection covers provide easy inspection and service access to internal engine components, such as the camshaft, rod and main bearings, valve train, etc. The crankcase covers are equipped with explosion relief valves. The cylinder block is designed for four, six, or eight point mounting.

Cylinder Head

The unit cylinder head is poured in compacted graphite iron at Caterpillar's foundry. The material approaches the strength of nodular iron, yet retains the heat transfer and sound damping properties of gray iron. It is a four valve, quiescent, uniflow port design with a central cast port for the unit fuel injector. The top deck is thick to carry gas loading while the buttressed bottom deck is thinner for good heat transfer. The replaceable valve guides are threaded to provide close tolerance with the valves and still have good lubrication control. All valves are fitted with positive rotators and seat on replaceable inserts. Fuel connections are made on the outside of the head with drillings to the unit fuel injectors. The head is retained by four hydraulically tensioned studs.

Valves

The valves seat on replaceable induction-hardened inserts. Positive rotators on all valves maintain a uniform temperature and wear pattern across the valve face and seat. Exhaust valves used in heavy fuel engines are given required special attention. By using a Nimonic 80A material in the valves and reducing the exhaust gas temperature, vanadium induced corrosion is significantly minimized. Increased valve overlap, water cooling the insert seats, and applying a ceramic coating to the valves maintains low valve head temperature.

Unit Fuel Injectors

The fuel injectors combine the pumping, metering and injecting elements into a single unit mounted directly in each cylinder head. This system has proven ideal not only when distillate and marine diesel oils are used, but also on heavy fuel; high injection pressure and precise injection timing, even at light loads, assure efficient combustion. Injection pressures of 1620 bar (23,500 psi) completely atomizes even the heaviest of fuels for more complete combustion and accelerated engine response. External manifolds supply fuel at low pressure from the transfer pump to drilled passages in the cylinder head. High pressure lines and double wall high pressure fuel injection lines are not needed. A 100 micron (.004 in.) edge type filter within each injector prevents contaminants from entering the injector during maintenance procedures. The hot water surrounding the injector location in the head aids in starting and stopping on heavy fuel. Individual control racks for each cylinder permits precise injector timing and minimizes fuel waste. Field calibration is eliminated and factory rebuilt injectors are available for engine overhaul.

An injector tip cooling system is used for heavy fuel operation.

Crankshaft

The crankshaft is a continuous grain flow forging, induction hardened, and regrindable. Counterweights at each cylinder are welded to the crankshaft and ultrasonically inspected to assure weld integrity. The crankshaft end flanges are identical, allowing full power to be taken from either end. A visconic crankshaft damper is fitted outside the engine housing at the free end of the engine.

Connecting Rods

Connecting rods are forged, heat treated, and shotpeened before machining. The special four bolt design and elimination of bearing grooves allows for an extra large bearing with reduced loads, and maximum oil film thickness. These factors extend bearing life and improve crankshaft strength and stiffness. The four bolt design also reduces bolt torque needed to achieve proper clamping load, and allows the rods to be withdrawn through the liner for service. Oil hole drilling in the critical rod shank area is eliminated by the use of piston cooling jets.

Bearings

All main, rod, and camshaft bearings are steel backed aluminum with a lead-tin overlay copper bonded to the aluminum. Piston cooling jets eliminate oil grooves in the highly loaded portion of the rod bearings.

Pistons

Pistons have a steel crown bolted to a light weight forged aluminum skirt for excellent strength and durability. Each piston has four rings, two in hardened grooves in the crown and two in the skirt. The top compression ring is barrel faced and plasma coated for greater hardness. The coating, in conjunction with the induction hardened liner, gives excellent oil control and life even with heavy fuel. The two middle rings are taper faced and chrome coated. The oil ring is chrome faced and uses a spring expander. Cooling oil for the crown and ring belt areas is sprayed from a cylinder block mounted jet through passageways in the piston.

Cylinder Liners

Cylinder liners are high alloy iron castings, induction hardened on the wearing surface, plateau honed and water jacketed over their full length.

Camshaft

The camshaft is segmented (one per cylinder) to permit easy removal and reduce service time. Each segment is made from case hardened, unique cleanliness controlled steel and bolted between two induction hardened journals. Only four unique camshaft segments are used for the entire engine family: (1) inline and vee right bank, (2) vee left bank, (3) standard overlap, and (4) high overlap for heavy fuel. Reverse rotation is accomplished by rearranging the segments.

Turbocharger

High efficiency turbochargers are used, one on the inline engines and two on the vee engines. The turbochargers have radial flow compressors and axial flow turbines. They are exhaust gas driven so that gear drives are not required. The turbocharger, combined with good "breathing" and efficient aftercooling, produces a high air/fuel ratio, providing more complete burning for maximum efficiency and improved cooling of the combustion chamber and valves. The turbochargers are water cooled and the bearings are pressure lubricated with engine oil.The turbochargers are mounted at the flywheel end of the engine. If a front mounted exhaust system is required, the engine can be turned end for end with full power taken from the front.

Exhaust System

The 3606 and 3612 Engines use a pulse exhaust manifold system. The manifold piping arrangement for the inline 3606 and each bank of the vee 3612 is identical. The front and rear three cylinders are connected to separate turbine inlet housing entries. The inline 3608 and the vee 3616 Engines use constant pressure exhaust systems. The 3608 has one manifold and the 3616 has one manifold for each bank.

Dry shielding assures surface temperatures meet Classification Society requirements.

Air Intake System

All engines are turbocharged and freshwater aftercooled. A variety of air cleaners can be supplied. The aftercoolers are mounted in air plenums cast directly in the cylinder blocks. Depending on the application, air shutoffs may be located in the air stream between the turbocharger and aftercooler.

Gear Trains

Gear trains are used at both the front and rear of the engines.

A. The rear gear group has 5 base HCR (High Contact Ratio) spur gears. The idler gear shafts are mounted to the rear of the block. The entire gear train can be removed with the rear housing in place. The vee gear train consists of seven gears with 5 being unique. The inline gear train consists of 4 unique gears.

B. The front gear group, identical for all four engines, is helical. The right idler drives the jacket water pump and the sea water pump. The left idler drives the water pump for the oil cooler and aftercooler. The gear train can be removed with the front housing in place.

Lube Oil System

The lube oil system, standard with the engine, features a prelube pump and a priority valve regulating oil pressure at the oil manifold rather than at the pump. This allows the engine to have continuous lubrication independent of pressure drop across the oil filters.

Oil Cooler and Filters

The oil cooler and filters are factory installed, tested and warranted, thus avoiding mixed responsibility for piping and components and significantly lowering installation costs. Duplex filters have replaceable elements allowing service without engine shutdown. The primary filter is 178 micron (.007 in.), while the final secondary filters are a media type of 5 micron (.0002 in.) size.

Oil Sump

The oil sump is of a light mild steel weldment bolted to the cylinder block. A wet type sump is normally used; a dry type can be provided to fit specific applications.

Bypass Oil Centrifuges

Bypass oil centrifuges, driven by main engine oil pump bypass flow, can be mounted on the side of the engine to remove very small, solid, micron size particles, and in some cases can be used to extend oil filter change periods. They can be cleaned and serviced with the engine running. They do not replace the need for separate lube oil centrifuges on heavy fuel burning engines.

Cooling System

Two basic cooling system configurations are available, single circuit and separate circuit. Both are designed for coolant supply temperatures of 90°C (194°F) (inlet control) to the water jacket, 32°C (90°F) to the aftercooler and 83°C (181°F) regulated temperature for the oil supply to the bearings. Both circuits include an engine mounted plate-fin aftercooler suitable for corrosive (salt air) environment. Both circuits include two water pumps that are engine driven from the front gear train and connections for vent lines to the high points in the system. The right-hand pump supplies coolant to the cylinder block, heads, and turbochargers. The left-hand pump supplies coolant to the aftercooler and oil cooler. An optional front gear train driven raw water pump for use with a remote heat exchanger is also available. Weld flanges are provided at all customer connection points.

Single Circuit

Single Circuit is typically used with a single heat exchanger and also with heavy fuel applications. The cylinder block/head/turbocharger cooling circuit is in series with the aftercooler/oil cooler circuit. It requires two main connections to the engine and includes 90°C (194°F) jacket water and 83°C (181°F) lubricating oil temperature regulators and two external circuit connections. The single circuit uses an external circuit temperature regulator and one external heat exchanger.

Separate Circuit

Separate Circuit is typically used for applications requiring small heat exchangers and/or heat recovery systems. The cylinder block/head/turbocharger cooling circuit is separate from the aftercooler/oil cooler circuit, and requires four main connections to the engine. This circuit includes a lubrication oil temperature regulator and external connections for both circuits. It requires a 90°C (194°F) and a 32°C (90°F) external circuit temperature regulator and two external heat exchangers.

Water Pumps

Water pumps are gear driven and located at the front of the engine. A special housing and impeller allow reverse rotation without changing the pumps. A gear driven raw water pump is also available to provide sea water to the heat exchanger.

Accessory Module

The accessory module shown in Figure 2 in the *Drawings* section provides standard locations for accessory mounting. The accessories are factory premounted on the module, with the complete module installed in one piece. This concept reduces installation time and cost. On diesel generator set applications the module will be floor mounted. It is used to mount the expansion tank, heat exchangers, instrument panel, engine controls, annunciator panel, alarm contactors, shutdown contactors and fuel strainers. On diesel generator set applications it is compatible with the 450 mm (17.72 in.) engine mounting feet dimension; connection lines to the accessories can be factory installed. Custom accessories can also be mounted on the accessory module on a space available basis.

Normally, the accessory module is mounted on the floor foundation directly in front of the engine. Flexible connections must be provided for the lines connecting the engine and the auxiliaries located on the separately mounted module.

When the module is mounted to other structures, and particularly when the engine is resiliently mounted, connections with increased flexibility may be necessary to accommodate engine motion. Flexible connections are provided by Caterpillar for the lines connecting the engine and the accessory module. Temperature contactors are available with 8 meter capillary tubes if the accessory module is to be remotely mounted. All other connections require custom modification to accommodate remote locations of the module.

Auxiliary Pumps

The oil and water pumps are gear driven and located at the front of the engine. A special housing and impeller allow reverse rotation without changing the water pumps. A gear driven sea (raw) water pump is available to supply cooling water to the fresh water heat exchanger.

Fuel Transfer Pump

Engines built for distillate fuel or marine diesel oils are equipped with an engine driven gear type transfer pump. For high viscosity fuels, an off engine mounted electrically driven pump is used to circulate fuel prior to engine start up.

Coupling

Marine torsional couplings are normally specified by the customer. They are available from Caterpillar. The selection for each marine application is dependent upon the Torsional Vibration Analysis. Customer specified couplings require Caterpillar approval.

Crankshaft Damper

Visconic crankshaft dampers are mounted outside the engine housing for optimum cooling and accessibility. Bolted covers and replaceable nylon bearings permit rebuilding in the field.

Flywheel

The flywheel is mounted at the rear of the engine and includes a ring gear for starting or barring. The high inertia flywheel is usually used for marine propulsion applications to permit the use of a single element flexible coupling.

Manual Turning Provision

Barring devices are provided to permit manual engine crankshaft rotation for service.

Engine Testing

Standard dynamometer production testing of 3600 Engines includes a comprehensive analysis of all engine systems. The following are standard points monitored during the test:

Engine Speed
Observed Power
Observed Torque
Observed Fuel Rate
Corrected Torque
Corrected Power
Corrected Fuel Rate
Corrected Specific Fuel Consumption
Full Load Correction Factor
Full Load Static Fuel Setting
High Idle Engine Speed
High Idle Stability
Low Idle Engine Speed
Low Idle Stability
Torque Check Speed
Inlet Air Pressure
Dry Barometric Pressure
Dew Point
Ambient Air Temperature
Inlet Air Temperature
Compressor Air Outlet Temperature
Inlet Air Manifold Temperature
Adjusted Boost Pressure
Oil Pressure
Oil Pressure at Low Idle
Bearing Oil Temperature
Fuel Pressure
Supply Fuel Pressure
Fuel Temperature
Return Fuel Temperature
Fuel Density
Jacket Water Inlet Temperature
Jacket Water Outlet Temperature
Delta T Jacket Water
AC/OC Inlet Water Temperature
AC/OC Outlet Water Temperature
Delta T AC/OC Water
Exhaust Manifold Temperature
Exhaust Stack Temperature

Depending on customer requirements, a variety of other engine tests are available including the following:

Marine Limit Line Test provides fuel rate, turbocharger boost pressure, specific fuel consumption, exhaust manifold gas temperature, turbocharger speed and fuel rack position at the engine's advertised rating limit line. Data is provided at 50 or 100 rpm increments from rated speed to 400 rpm. The test is intended for controllable pitch propeller applications.

Propeller Demand Curve Test provides fuel rate, turbocharger boost pressure, specific fuel consumption, exhaust manifold gas temperature, turbocharger speed and fuel rack position at the engine's advertised fixed pitch propeller demand curve. Data is provided at 50 or 100 rpm increments from rated speed to 400 rpm.

Overload Test provides fuel rate, turbocharger boost pressure, specific fuel consumption and fuel rack position at a customer specified temporarily increased power setting (overload). The engine fuel rack stop is reset to the proper power level upon test completion.
A full description of standard available tests is found in the Selection Guide, LEBQ5043-01.

Marine Classification Society Certification

Caterpillar has approvals for 3600 engines from the major marine Classification Societies listed below:

Approvals	Type	Works
American Bureau of Shipping (United States)	x	x
Lloyd's Register of Shipping (Great Britain)	x	x
Bureau Veritas (France)	x	x
Det Norske Veritas (Norway)	x	x
Germanischer Lloyd (Germany)	x	x
Nippon Kaiji Kyokai (Japan)	x	x
Registro Italiano Navale (Italy)	x	x
USSR Register of Shipping (Soviet Union)	x	x
Canadian Coast Guard (formerly CBSI)		x
Zhong Chuan (China) —3606 & 3608 only		x

Certifications from other Societies are available on request.

Torsional Vibration Analysis

To ensure the compatibility of an engine and driven equipment, a theoretical torsional vibration analysis is required. Disregarding the compatibility of the engine and driven equipment can result in extensive and costly damage to drive train components.

Conducted during the design stage of a project, the torsional analysis can avoid torsional vibration problems through modification of driven equipment shafts, masses or couplings. The torsional report will show natural frequencies, significant resonant speeds, relative amplitudes and a determination of stress levels, and the approximate nodal locations in the mass elastic system for each significant natural frequency.

The following technical data is required to perform a torsional analysis:

1. Is the application a variable or a constant speed operation? If variable, what is the operating speed range?
2. Load curve on installations for applications using load dependent variable stiffness couplings.
3. Horsepower requirements of each set of equipment is required when driving equipment from both ends of the engine. Are front and rear loading occurring simultaneously?
4. A general sketch of the complete system showing the relative location of each piece of equipment and type of connection.
5. Identification of all couplings by make and model along with rotating inertia (WR^2) and torsional rigidity values.
6. Rotating inertia (WR^2) or principal dimensions of each rotating mass and the location of the mass on the attached shaft.
7. Weight or principal dimensions of driven reciprocating mass.
8. Torsional rigidity and minimum shaft diameter or detailed dimensions of all shafting in the driven system, whether separately mounted or installed in a housing.
9. The number of propeller blades in addition to the rotating inertia (WR^2) in water.
10. The ratio of the speed reducer or increaser. The rotating inertia (WR^2) and rigidity submitted for a speed reducer or increaser should state whether or not they have been adjusted by the speed ratio squared.

Since compatibility of the installation is the customer's responsibility, it is also his responsibility to obtain the theoretical Torsional Vibration Analysis. Data on mass elastic systems of items furnished by Caterpillar is shown in the following tables. Damper selection for marine propulsion engines is shown in Figure 3. Always consult TMI for current data. The customer can calculate theoretical torsional vibration analysis or hire Caterpillar Inc. to complete the analysis. A *3600 Torsional Vibration Analysis Request* form is provided as a guide to the type of information required to complete the analysis (see Figure 4).

Marine Propulsion Damper Criteria				
rpm	3606	3608	3612	3616
750	A1	A2		B3
800	A1	A2	C2	B3
900	A1	C1	C2	B3
1000	A1	C1	C2	B3

Marine Auxiliary Damper Criteria				
rpm	3606	3608	3612	3616
720	A1	A2	B1	B3
750	A1	A2	B1	B3
900	A1	C1	C2	A3
1000	A1	C1	C2	A3

Two bearing generators only

Damper Data	A1	A2	A3	B1	B2	B3	C1	C2
Lumped mass J*	6.1	6.1	6.1	23.1	23.1	23.1	26.2	26.2
Separated Damper Data								
Damper Housing J*	3.2	3.2	3.2	8.6	8.6	8.6	11.6	11.6
Damper Flywheel J	5.8	5.8	5.8	28.9	28.9	28.9	29.2	29.2
Damper Constant C	1243	1000	1550	5100	6600	8100	14123	7000
Damper Rigidity K	0.73	0.41	0.60	1.80	1.60	1.35	4.52	2.85

* Add to Front of Crank

J (N-m -sec^2)

K (N-m x 10^6/radian)

C (N-m-sec sec/radian)

Torsional Calculation Values

Reciprocating Mass per Cylinder = 68.36 kg

Rotating Mass per Cylinder = 39.61 kg

Connecting Rod Length (between pin centers) = 600 mm

Cyclic Irregularity

The calculated cyclic irregularities for 3600 are:

Engine	Speed-rpm 900	1000
3606	1:152	1:188
3608	1:145	1:179
3612	1:254	1:314
3616	1:450	1:556

Figure 3

Empirical Damping

For torsional calculations involving empirical damping the empirical damping values are:

Engine	N-m-sec per radian
3606	384
3608	441
3612	531
3616	531

Note: *The damping values for the inline engines are for each cylinder; the 3612 and 3616 damping values are for a pair of cylinders since the vee engines have two cylinders on each crankshaft throw.*

Flywheel Inertia Data

Most marine propulsion applications use the high inertia flywheel to allow the use of a single element torsional coupling. A lighter weight standard flywheel is also available. Inertia valves include the ring gear and should be added to the rear crank inertia.

Standard flywheel inertia: 74.90 N-m-sec^2

High inertia flywheel: 140.29 N-m- sec^2

Torsional Vibration Data - Model 3606

Front Driven Equipment Visconic Damper – See page 18

3606 Mass Elastic System

Degrees to Firing After #1 Fires	Engine	J	K
	Front Crank	7.50	
			72.53
0	Cyl #1	9.743	
			42.85
480	Cyl #2	8.685	
			42.85
240	Cyl #3	8.685	
			42.85
600	Cyl #4	8.685	
			42.85
120	Cyl #5	8.685	
			42.85
360	Cyl #6	9.743	
			72.53
	Rear Crank	7.42	

Units

J = N-m-sec^2

K = $\frac{\text{N-m x } 10^6}{\text{Radian}}$

C = $\frac{\text{N-m-sec}}{\text{Radian}}$

Diameter in Millimeters

For Harmonic Component of Tangential Pressure See TD3310

Total Inertia Without Flywheel and Damper: J = 69.15 N-m-sec^2

Torsional Vibration Data - Model 3608

Front Driven Equipment Visconic Damper – See page 18

3608 Mass Elastic System

Degrees to Firing After #1 Fires	Engine	J	K	Min. Dia.
	Front Crank	7.50		
			69.28	216
0	Cyl #1	12.95		
			41.50	216
180	Cyl #2	4.79		
			41.50	216
450	Cyl #3	4.79		
			41.50	216
630	Cyl #4	12.21		
			41.50	216
270	Cyl #5	12.21		
			41.50	216
90	Cyl #6	4.79		
			41.50	216
540	Cyl #7	4.79		
			41.50	216
360	Cyl #8	12.95		
			69.28	216
	Rear Crank	7.42		

Units

J = N-m-sec^2

K = $\frac{\text{N-m x } 10^6}{\text{Radian}}$

C = $\frac{\text{N-m-sec}}{\text{Radian}}$

Diameter in Millimeters

For Harmonic Component of Tangential Pressure See TD3310

Total Inertia Without Flywheel and Damper: J = 84.40 N-m-sec^2

Torsional Vibration Data - Model 3612

Front Driven Equipment Visconic Damper – See page 18

3612 Mass Elastic System

Degrees to Firing After #1 Fires		Engine	J	K	Min. Dia.
		Front Crank	7.50		
				67.79	216
1R-0	1L-410	Throw #1	17.00		
				40.11	216
2R-480	2L-170	Throw #2	16.31		
				40.11	216
3R-240	3L-650	Throw #3	16.31		
				40.11	216
4R-600	4L-290	Throw #4	16.31		
				40.11	216
5R-120	5L-530	Throw #5	16.31		
				40.11	216
6R-360	6L-50	Throw #6	17.00		
				67.79	216
		Rear Crank	7.42		
					216

Units

J = N-m-sec^2

K = $\frac{\text{N-m x } 10^6}{\text{Radian}}$

C = $\frac{\text{N-m-sec}}{\text{Radian}}$

Diameter in Millimeters

For Harmonic Component of Tangential Pressure See TD3310

Total Inertia Without Flywheel and Damper: J = 114.16 N-m-sec^2

Torsional Vibration Data - Model 3616

Front Driven Equipment Visconic Damper – See page 18

3616 Mass Elastic System

Degrees to Firing After #1 Fires		Engine	J	K	Min. Dia.
		Front Crank	7.50		
				67.79	216
1R-0	1L-50	Throw #1	17.17		
				40.11	216
2R-180	2L-230	Throw #2	16.5		
				40.11	216
3R-90	3L-140	Throw #3	16.5		
				40.11	216
4R-630	4L-680	Throw #4	16.5		
				40.11	216
5R-270	5L-320	Throw #5	16.5		
				40.11	216
6R-450	6L-500	Throw #6	16.5		
				40.11	216
7R-540	7L-590	Throw #7	16.5		
				40.11	216
8R-360	8L-410	Throw #8	17.17		
				67.79	216
		Rear Crank	7.42		

Units

J = N-m-sec^2

K = $\frac{\text{N-m x } 10^6}{\text{Radian}}$

C = $\frac{\text{N-m-sec}}{\text{Radian}}$

Diameter in Millimeters

For Harmonic Component of Tangential Pressure See TD3310

Total Inertia Without Flywheel and Damper: J = 148.26 N-m-sec^2

3600 Torsional Vibration Analysis Request

Project Number ______________________________

Project/Customer Name ______________________________

Dealer Name ______________________________

The information on this form is to be used for a specific request for a torsional vibration analysis on the above 3600 Diesel Engine application. Please provide a timely verbal response followed by a written report to the responsible project engineer. The following information describes the major components and performance data for this application:

Engine Model and Rating:

E29 ________ (36 ________); ________ kW (________ bhp)

Low Idle rpm ________ Rated Speed rpm ________

Engine Regulation: Isochronous (Y/N) ________, or Percent Droop ________ %

Application Specifics:______________________________

____

____

(quantity engines -- custom base -- front driven equipment, etc.)

Engine Room Maximum Ambient Temperature ______________________________

Generator (____); and/or **Marine Gear** (____); plus **Other Driven Equipment** (____)

Supplier Name and Model Number ______________________________

Rotating Inertia/Drawing(s) ______________________________

Rotating Stiffness/Shaft Drawing(s) ______________________________

Gearbox Drawing ____________________ Propeller Inertia ____________________

Description (e.g. two bearing or single bearing)______________________________

____

(attached are supplier data sheets)

Part Numbers of Components:

Engine Ship Date (RTS) ______________________________

Flywheel Group	___________	Coupling Group	___________
Drive Group	___________	Damper Group	___________
Ring Gear Group	___________	Other Groups	___________
3161 Governor Group	___________	Heinzmann Governor	___________
EGB29P Actuator Assembly	___________	Electronic Control Group	___________

Torsional Completion Date Required ______________________________

Caterpillar Project Engineer ______________________________

(Revised 4-25-97)

Figure 4

Engine Preservation and Packaging

The Caterpillar factory has four standard levels of engine preservation and shipment protection.

- *Plastic Shrink Wrap Protection* provides approximately one year of external protection from moisture, sun and wind under storage conditions. If the engine is to be stored for longer periods of time, consider specifying Storage Preservation as described below.
- *Tarpaulin and Plastic Shrink Wrap* – Same as previous point above except this package includes a factory supplied tarpaulin on the engine, which remains on the engine after arrival.
- *Storage Preservation* – Protects the engine and accessories from functional deterioration for a minimum of one year under outside storage conditions. It includes standard protective measures plus vapor corrosion inhibitor (VCI) in all internal compartments and glycol solution in the cooling system. The shipper must provide tarpaulin coverage during transportation to prevent the plastic from being destroyed.
- *Export Boxing* – Protects engine and accessories from functional deterioration for a minimum of one year under outside storage conditions. Includes standard protective measures plus vapor corrosion inhibitor in all internal compartments, and a glycol solution in the cooling system. The exterior box provides protection against mechanical damage during shipment and storage. All marine engines are placed upon wooden skids prior to shipment. All ship loose parts are prepainted, oiled and placed in VCI paper lined boxes, with desiccant packages placed in the box. On arrival, open all boxes and review their contents against the packing list. The parts should then be repackaged and preserved for protection.

Shipbuilder's Responsibility

Unless otherwise specified, the engine buyer shall be responsible for the following:

- Provide electrical wiring and the necessary piping to the engine, i.e., exhaust piping, fuel oil piping to and from the engine, air piping to the starting motor(s), air filter ducting/piping, crankcase fumes disposal ducting, etc.

  All of the above noted interconnections need to be designed in such a way so as to comply with acceptable vibratory levels of excitation throughout the entire range of engine operation. No primary resonances in the interface hardware are acceptable. See ISO 4868 and 4867.
- Furnish and install standby pumps as required by Classification Societies.
- Furnish accurate data for a torsional vibration analysis.
- Install adequate engine foundation and provide proper chocking and alignment between the engine and marine gear.
- See ISO 10816-6 and ISO 6954. Typically, vibratory velocities under 10 mm/s with no structural resonances are required.
- Ensure all lube oil piping, fuel oil piping, exhaust piping and intake air ducting are free of rust, scale, weld spatter and foreign material prior to startup of the engines.
- Provide all labor, equipment and hardware to install the equipment.
- Provide all coolants, water treatment chemicals (if used), lubricating oil, and fuel oils necessary to operate the engine.
- Warehouse and protect engines, accessories and miscellaneous ship-loose equipment until their installation. Caterpillar engines are protected against corrosion for inside dry storage for a period up to six months. Provisions for additional storage periods are available from the factory.

Customer Application Information

Customer:____________________________ Address: ____________________________

Contact: ________________________________ Telephone: ____________________________

Shipyard: ______________________________ Contact: ____________________________

Address: ______________________________ Telephone: ____________________________

1. Main Engine: ____

   Engine output: ______________________ kW (hp) Speed: ______________________rpm

   Direction of rotation (flywheel viewed from rear): ________________________________

   Fuel Type: ____

   Builder: ____

   Special testing Yes/No: ____

2. Propulsion controls:

   Type (pneumatic/electronic): ____

   Manufacturer: ____

3. Combined clutch/flexible coupling (type): ________________________________

   Flexible coupling: ____

4. Reduction gear box, manufacturer and type: _____________________________

   Reduction ratio: ______________________________

   Integral disc clutch? Yes____ No____ Clutch type: pneumatic/hydraulic

   PTO? Yes____ No____ Manufacturer ______________________________

   Shaft Brake? Yes____ No____

5. Propeller manufacturer: ____

   Type: Fixed pitch ____________________

   Controllable pitch ____________________

   Number of blades ____________________ Propeller Diameter:________mm_________in.

   P/D Ratio: __________________________ Blade Area Ratio: ________________________

   Propeller speed at MCR rating __________________________rpm

   Direction of propeller rotation ____

   Designed for constant rpm? Yes______________________No______________________

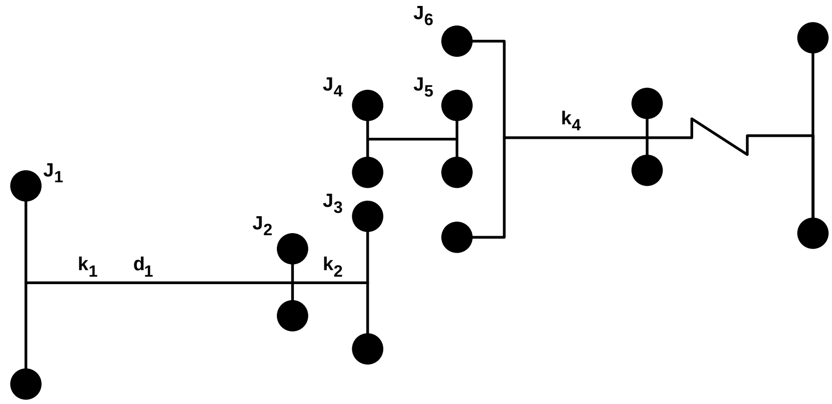


Figure 5

6. Data For Torsional Vibration Calculations

J_1 Propeller	J_2 Gear box flange	J_3 Gear wheel
J_4 Gear wheel	J_5 Clutch	J_6 Clutch

Propeller Inertia J (N-m-sec^2) without entrained water____________________N-m-sec^2

7. Vessel hull type____

Length:______mm ______in. Beam: ______mm ______in. Draft:_____mm______in

Displacement______________________m.t. Class of service: ______________________

Hull speed_________________________kts. Classed by:___________________________

Materials and specifications are subject to change without notice.

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